In re Patent Application of:
DUELLI
Serial No. **10/098,585**
Filed: **MARCH 15, 2002**
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REMARKS

The applicant would like to thank the examiner for reconsidering the finality of the rejections of the last office action and for withdrawing the finality.

Claims 1-6 are now pending in this application.

Claims 1 and 4-6 are rejected under 35 U.S.C. § 103 (a) as being unpatentable over United States Patent No. 6,445,939 to Swanson et al.

Claims 1 and 4 have been amended.

The examiner points out that Swanson et al. do not appear to disclose that GRIN lens (2) is a section of graded index fiber, and that it would have been obvious to one of ordinary skill in the art at the time the invention was made to use a GRIN lens instead of a section of Graded index fiber for their use in the optical coupling art. The examiner takes official notice of the equivalence of a GRIN lens and a second of graded index fiber for their use in the optical coupling art.

Pending Claim 1 of the instant invention defines:

1. A fiber-optic optical coupling assembly comprising:
   a) a first optical waveguide having a first terminal end, b) a section of graded index fiber, wherein the first terminal end of said graded index fiber is in optical communication with the first terminal end of

the first optical waveguide whereby an optical beam propagating from the first terminal end of the first optical waveguide and exiting the second terminal end of the graded index fiber is reduced to a diameter d at distance from the terminal end of the graded index fiber L, wherein d is less than about 30 microns and L is greater than about 220 microns.

The applicant in the disclosure of the instant application has described and shown the invention in a preferred embodiment exemplified by Fig. 1, shown below.

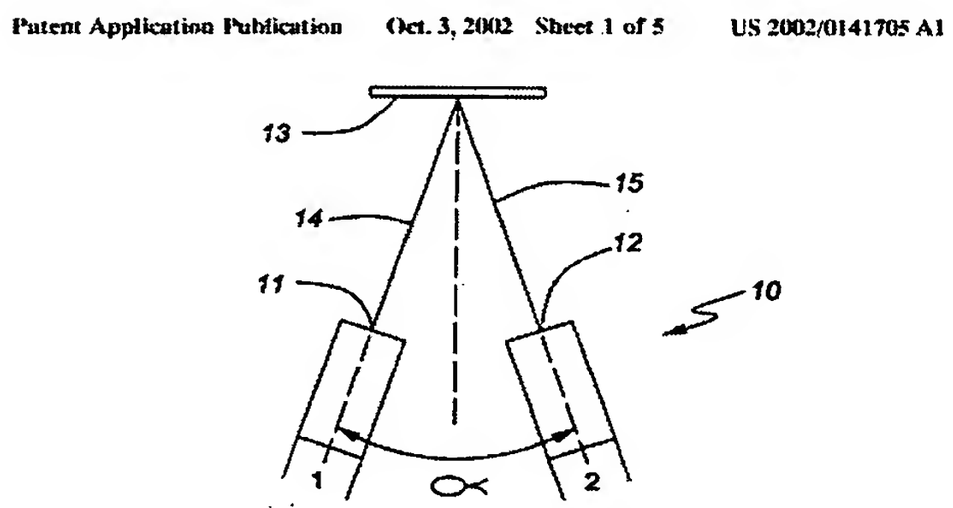

FIG. 1

In the disclosure the following description is found at col. 2 para [0011]
"FIG. 1 illustrates the benefits of the inventive optical coupler in forming a high interconnection density device 10. Optical signals arriving from waveguide 1 are transmitted to waveguide 2 after reflection of surface 13 in device 10. To avoid signal losses the optical power arriving from waveguide 1 must be efficiently coupled between device input port 11 and device output port 12. Light emitted by the waveguide 1 must be fully collected at output port 12 for re-transmission via waveguide 2 after reflection at

surface 13. The inventive optical coupler modifies the free space propagation of light emitted by waveguide 1 and the collection of such light into waveguide 2 such that ports 11 and 12 may be considered object and image points separated by a working distance (WD) equal to the length, L, of segments 14 and segment 15, i.e. WD equals 2L."

It is highly advantageous to have a fiber coupling between two fibers wherein light is coupled between the two fiber ends via a reflecting surface, and wherein the waist of the beam propagating between the two fibers, at a distance L, is at the location of the reflector.

Claim 1 has been amended to reflect this novel, inventive, and advantageous configuration.

Amended claim 1 now recites:

A fiber-optic optical coupling assembly comprising:
a) a first optical waveguide having a first terminal end,
b) a <u>first</u> section of graded index fiber <u>having a first terminal end and a second terminal end</u>, wherein the first terminal end of said graded index fiber is in optical communication with the first terminal end of the first optical waveguide whereby an optical beam propagating from the first terminal end of the first optical waveguide and exiting the second terminal end of the graded index fiber is reduced to a diameter d at

distance from the terminal end of the graded index fiber L, wherein d is less than about 30 microns and L is greater than about 220 microns;

c) a second optical waveguide having a first terminal end,

d) a second section of graded index fiber having a first terminal end and a second terminal end, wherein the first terminal end of said second graded index fiber is in optical communication with the first terminal end of the second optical waveguide whereby the second optical waveguide and the second section of graded index fiber have substantially same characteristics as the first optical waveguide and the first section of graded index fiber, respectively; and,

e) a reflective surface disposed a distance L from the second terminal end of the first graded index fiber and disposed a distance L from the second terminal end of the second graded indeed fiber.

Claim 1 now defines two optical waveguides having ends with characteristics that provide a waist or small beam spot size of less than about 30 microns a distance L from the fiber ends. The claim further defines a reflector located at a target location between the two ends a distance L from both. The invention now defined by claim 1 has significant advantages. Coupling between the two waveguides is highly efficient and the size of the reflector can be minimized by this embodiment. Small size is extremely important in the telecommunications domain, especially in optical switching devices such as MEM's devices.

The cited reference makes no mention of coupling light from one waveguide to another and is absent any teaching of coupling light between waveguides via a mirror; and more particularly of placing the mirror a distance L at the waist of the beam exiting the waveguide.

The instant application makes further reference in paragraph 36 to the usefulness of this arrangement now claimed.

"[0036] The inventive coupler is preferably used in a compact optical switch or crossconnect that is fabricated from a monolithic substrate, such as silicon, wherein the photolithography methods can be used to fabricate optical components, preferably translatable mirrors, and the associated actuator devices. The small spot size of the inventive optical coupler allows fixed or translatable mirrors to be reduced in size accordingly." Underlining added for emphasis.

The applicant believes that this combination of optical waveguides having graded index fiber with the characteristics claimed, a spot size of less than about 30 microns and a length L greater than about 220 microns having a reflector disposed there between a length L away from the end faces of the graded index fiber, is patentable over Swanson et al. who are attempting to solve a different problem. Swanson et

al. provide a single optical fiber, wherein a high powered beam exiting the fiber has a small cross section a distance away, for providing a small optical probe. Swanson et al. are concerned with providing a probe with an output beam having particular characteristics. Ensuring that the waist is at a particular distance from the lens, and that the spots size is a particular size provides an avenue to obtaining a desired output beam for the probe.

This instant invention as was pointed out above, is concerned with providing a small spot size on a reflector between two waveguides, for example to provide an very small optical switch.

Claims 2 and 3 are rejected under 35 U.S.C. § 103 (a) as being unpatentable over United States Patent No. 6,445,939 to Swanson et al., in view of Ukarainczyk et al.

Claim 2 has been amended as follows:

2. A fiber-optic coupling assembly according to claim 1 ~~further comprising an optical spacer selected from the group consisting of; a. an air gap, an oxide of silicon, index matching fluid and an index matching gel, wherein the optical spacer is between the first terminal end of said optical waveguide and the first terminal end of said graded index fiber,~~ wherein the first optical waveguide is a single mode optical fiber and ~~whereby the optical beam is expanding from the core section of the single~~

~~mode optical fiber prior to entering said gradient index fiber section~~ wherein the coupling assembly forms a part of an optical switch or cross connect.

Claim 2 dependent on amended claim 1 is believed to be patentable.

Claim 3 has been amended to incorporate the limitations of claim 2 prior to the amendment above.

3. A fiber-optic coupling assembly according to claim 1 further comprising an optical spacer selected from the group consisting of; a. an air gap, an oxide of silicon, index matching fluid and an index matching gel, wherein the optical spacer is between the first terminal end of said optical waveguide and the first terminal end of said graded index fiber, whereby the optical beam is expanding from the core section of the single mode optical fiber prior to entering said gradient index fiber section ~~A fiber-optic coupling assembly according to claim 2~~ wherein the optical spacer comprises a thin film coating.

Claim 4 has been rejected.

The examiner has stated that Swanson discloses the limitations of claim 4, but does not disclose that the graded index lens has an index of refraction gradient characterized by a change in refractive index of less than about 0.009 over a core diameter of about 80 microns. It is further stated in the office action that it would have been obvious to one of ordinary skill in

the art at the time the invention was made to design the graded index fiber to have a suitable index of refraction gradient over a certain core diameter.

The applicant respectfully disagrees with the examiner on this point. A graded index lens has been discovered and defined in claim 4, that provides distinct advantages in telecommunications applications for example for use in a small optical switch wherein mirrors must be kept small and yet capture all of the light transmitted between two lensed optical waveguides. The refractive index profile specified is a discovery and no hint or suggestion of this is found in any of the cited references. Notwithstanding, the applicant has amended claim 4, to limit it to having two such waveguides, and a reflective element disposed therebetween.

Amended claim 4 now defines:

4. A fiber-optic optical coupling assembly comprising:
a) a first optical waveguide having a first terminal end,
b) a first section of graded index fiber having index of refraction gradient characterized by a change in refractive index of less than about 0.009 over a core diameter of about 80 microns[[;]] wherein ~~the~~ a first terminal end of said graded index fiber is in optical communication with the first terminal end of the first optical waveguide[[;]] whereby an optical beam propagating from the first terminal end of the first optical waveguide and exits ~~the~~ a second terminal end of the graded index fiber;

c) a second optical waveguide; and,

d) a second section of graded index fiber, wherein the second optical waveguide and the second section of graded index fiber are in optical communication with each other, the second optical waveguide and second section of graded index fiber having substantially same physical characteristics as the first optical waveguide and first section of graded index fiber, respectively; and,

a reflective element disposed to receive a beam exiting the second terminal end of the first graded index fiber and reflect said light to an outer end face of the second section of graded index fiber, wherein the reflective element is disposed at a distance L from the two graded index fibers such that a waist of the beam is located at the reflective element.

In view of the novelty and invention in original claim 4 and further in view of the novel and inventive arrangement of two such special lensed waveguides and their juxtaposition to a reflector, claim 4 is believed to be clearly distinguish and define an inventive combination over all known prior art.

Claims 5 and 6 import the limitations from amended claim 4 from which they depend and are now believed to be patentable.

Reconsideration of this application is respectfully requested.

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Should any minor informalities need to be addressed, the Examiner is encouraged to contact the undersigned attorney at the telephone number listed below.

Please charge any shortage in fees due in connection with the filing of this paper, including Extension of Time fees, to Deposit Account No. 50-1465 and please credit any excess fees to such deposit account.

Respectfully submitted,

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I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: M/S Amendment, Commissioner for Patents, P. O. Box 1450, Alexandria, VA 22313-1450, on this 16 day of August, 2004.